



# **Armed Forces College of Medicine AFCM**



# **Respiratory System**

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# INTENDED LEARNING OBJECTIVES (ILO)



*By the end of this lecture, you should be able to:*

- Correlate structure of the **bronchioles** to their functions.
- Correlate structure of the **Clara cells** to its functions.
- Describe the structure and correlated functions of the **alveolar ducts and alveolar sacs**.
- Describe the structure and correlated functions of **the alveoli**.
- Describe the structure and correlated functions of the **inter-alveolar septum, and the blood air barrier**.
- Describe the structure and correlated functions of the **alveolar epithelium (pneumocyte I and pneumocyte II)**.

3 • Describe the origin, structure and correlated



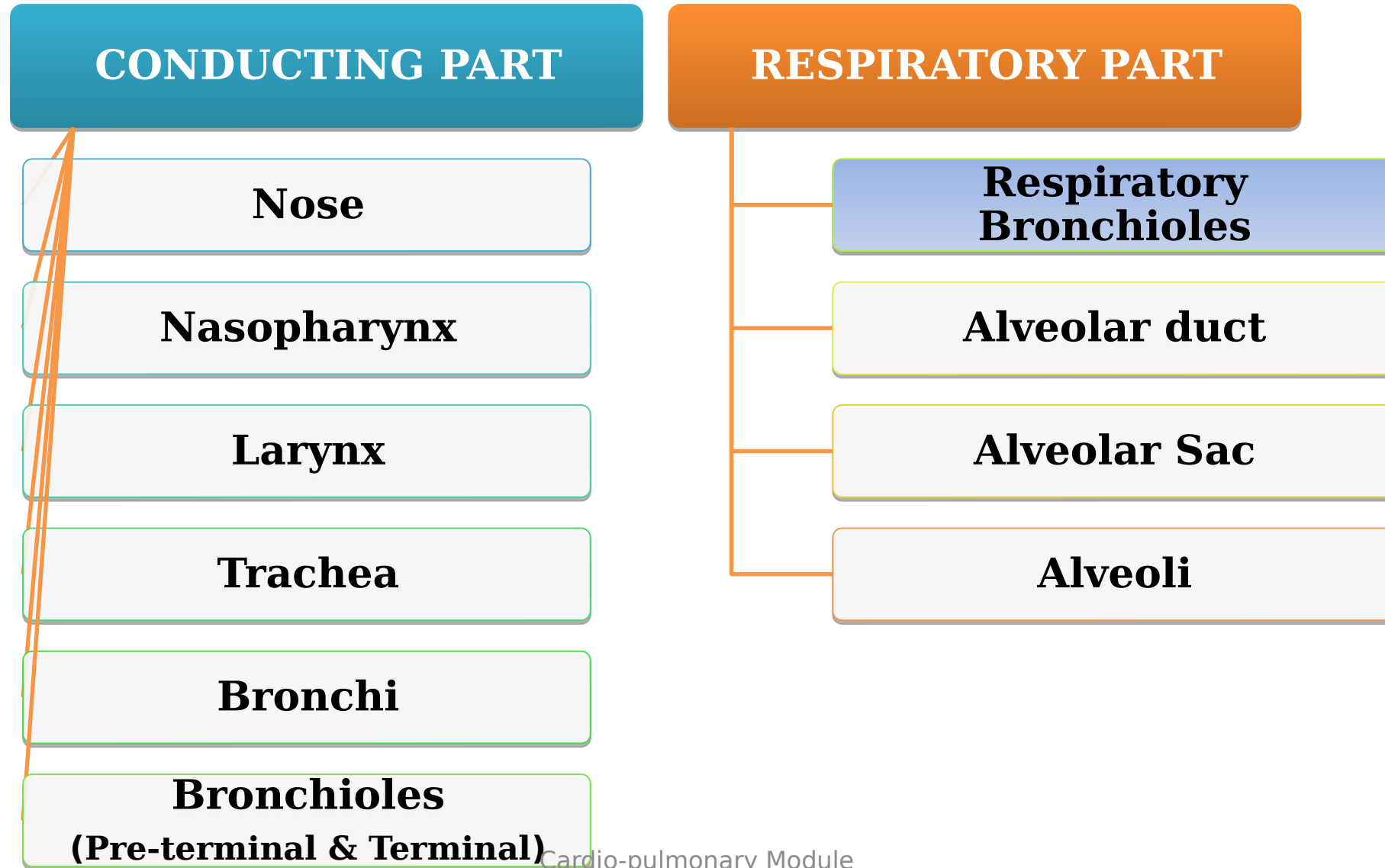
## **1.Part 1 (5 min) Introduction**

## **2.Part 2 (35 min) Main lecture: Key points:**

- Structure of the bronchioles.
- Clara cells.
- Respiratory bronchioles, alveolar ducts, alveolar sacs.
- Structure of the alveoli.
- Pneumocytes types I&II.
- Inter-alveolar septum and blood air barrier.
- Alveolar macrophages.

## **3. Part 3 (5 min) Summary**

# Components of Respiratory System





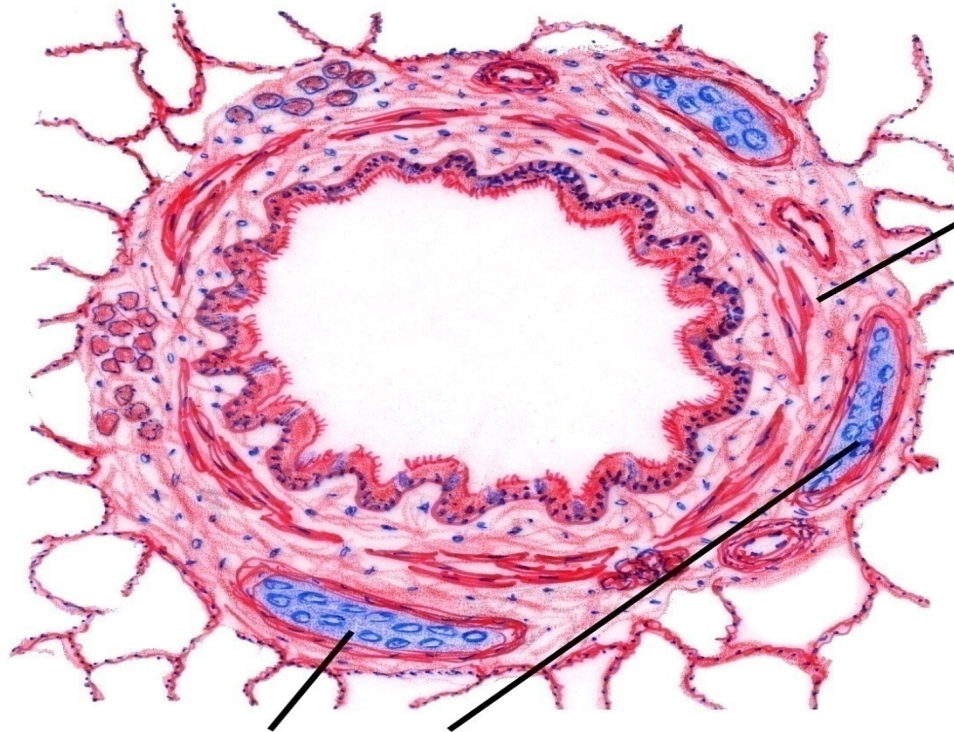
# Bronchi

(as they branches)

smooth ms f. ↑ •  
elastic fibers ↑ •

cartilage ↓ •  
goblet cells ↓ •

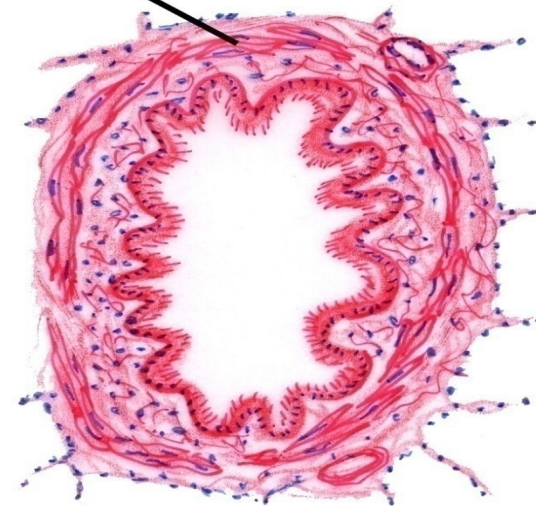
## BRONCHUS



**Cartilage plates**

## BRONCHIOLE

**Smooth muscle**



# 6- Bronchioles

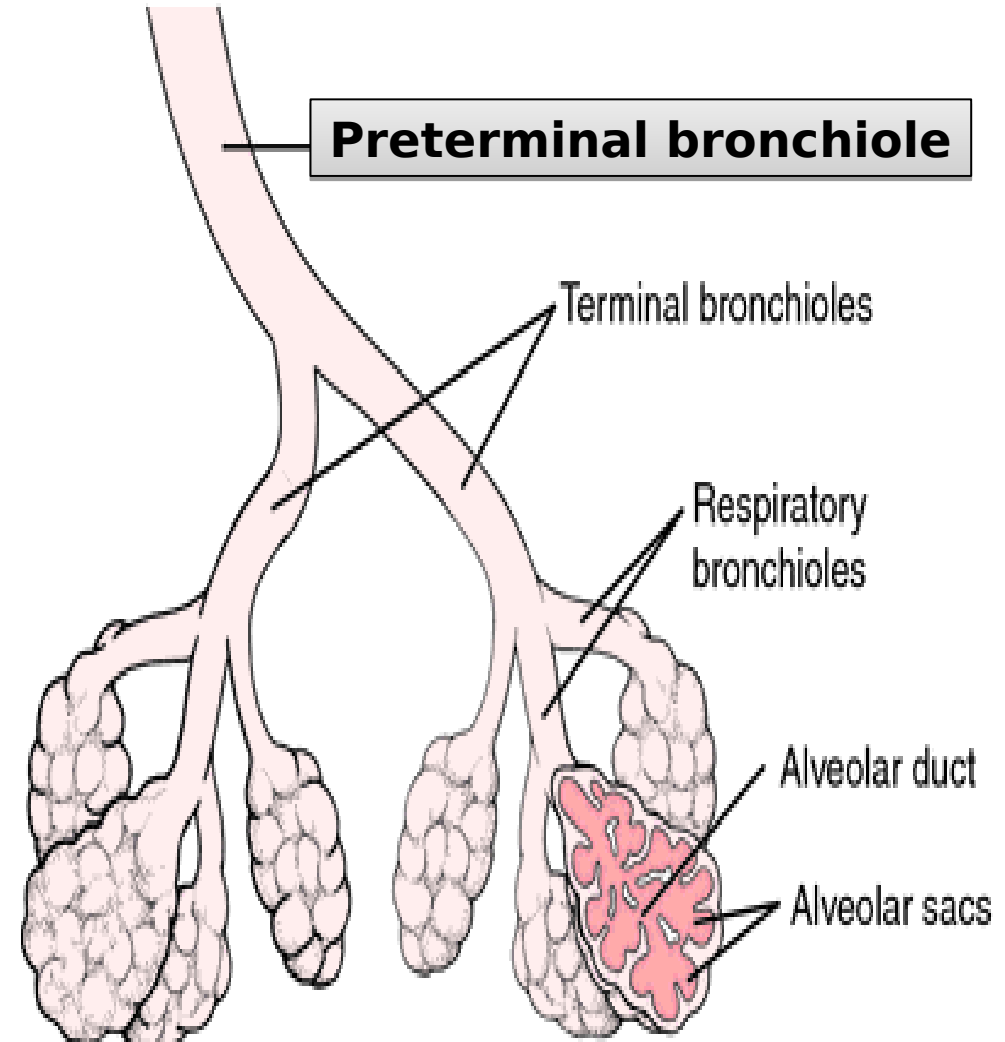


They are three types:

**1-Preterminal  
(primary) bronchioles  
(1 mm)**

**2-Terminal bronchioles  
(0.5mm)**

**3-Respiratory  
bronchioles (0.2mm)**



# 6- Bronchioles



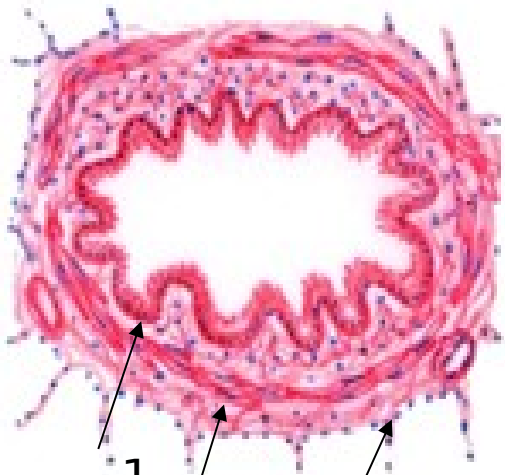
## Pre-terminal & terminal bronchioles

### Mucosa(1

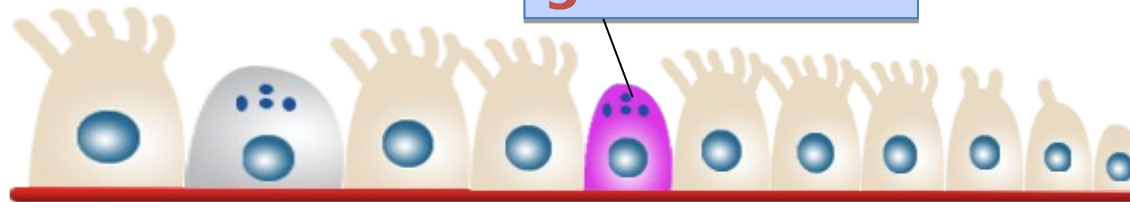
Simple columnar ciliated **epithelium** with non ciliated **Clara (club) cells** & few goblet cells.

**Lamina propria:** thin elastic CT with **no glands.**

Clara



.1  
Mucosa  
Muscle .2  
layer  
Adventitia.3



- ❖ The cilia gradually disappear as bronchiole become small.
- ❖ Goblet cells disappear just before the level where cilia disappear **to avoid accumulation of secretions.**

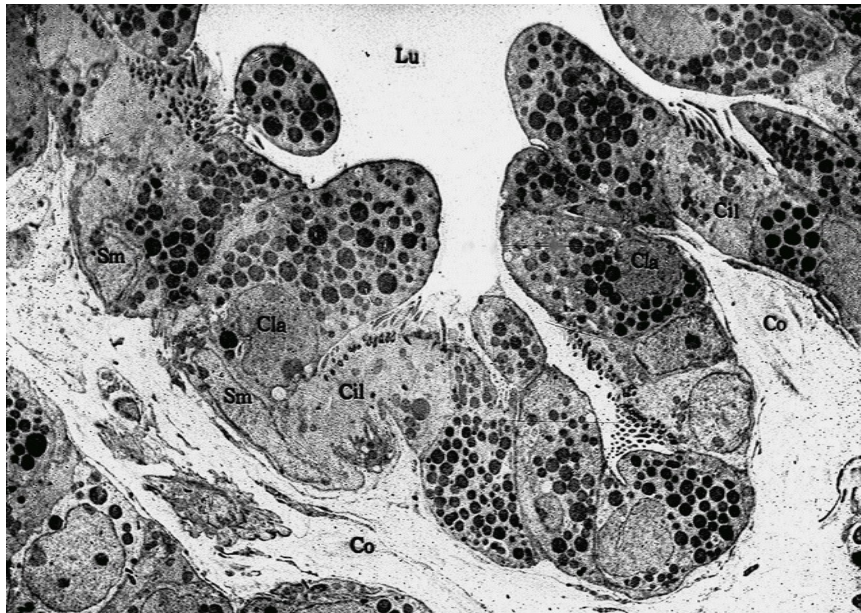


# 6- Bronchioles



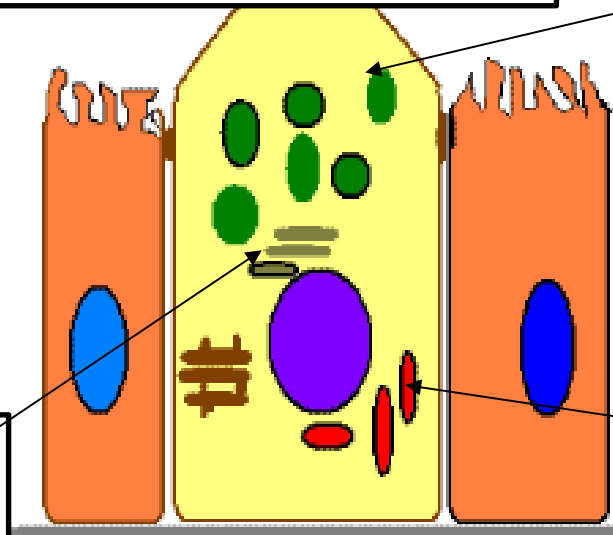
## Clara cells (Club Cells)

They are present in large bronchioles, between the ciliated cells.



**Non ciliated  
columnar dome-  
shaped cell that  
project above  
other cells**

**Apical  
secretory  
granules.**



**Supranuclear  
Golgi, rER**

**Numerous  
mitochondria and  
sER???**

## 6- Bronchioles



### Clara cells (Club Cells)

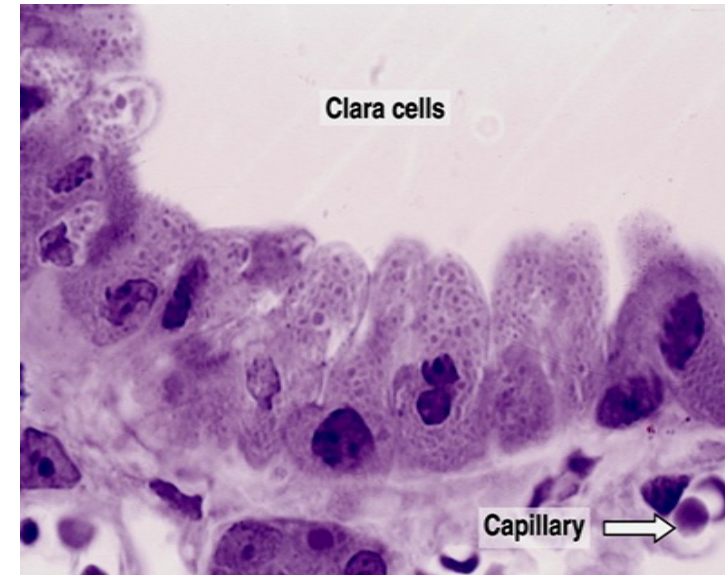
- **Function:-**

1. It produces **surfactant like material** → reduce the surface tension of the bronchioles → prevents their collapse

2. Can divide to **regenerate** bronchiolar ep.

3. It can **metabolize air-borne**

<https://oneclass.com/class-notes/ca/western/anat-cell-bio/acb-3309/1293117-anatomy-and-cell-biology-3309-lecture-4.en.html>

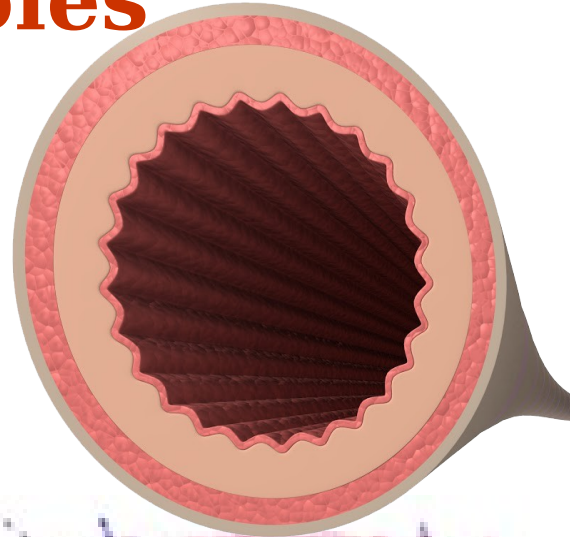


**Clinical Correlate:** Cystic fibrosis can result in abnormally thick mucous, in part due to defective chloride transport by Clara cells

## 6- Bronchioles

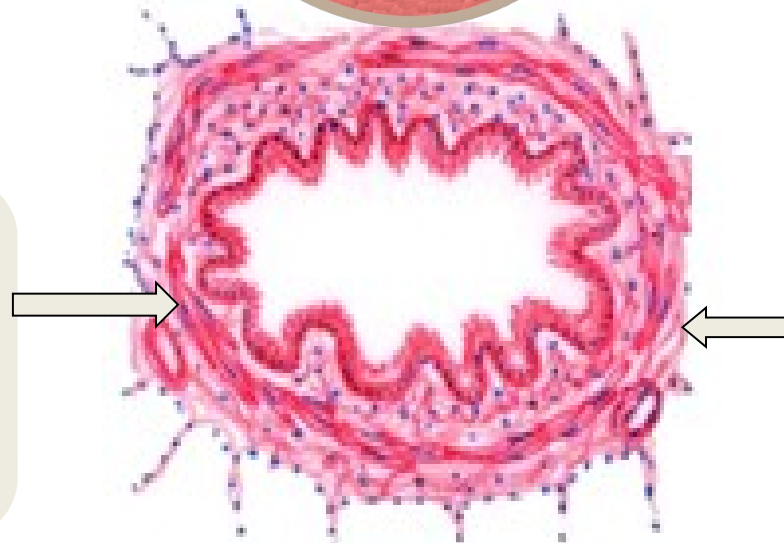


### Pre-terminal & terminal bronchioles



#### **2) Muscle layer:**

Spirally arranged smooth muscle fibers.



Cardio-pulmonary Module

#### **3) Adventitia:**

Fibro-elastic CT with

- **No glands**
- **No cartilage**
- **No lymphoid follicle**

## 6- Bronchioles



Note

### **Bronchioles** (as they branches)

- **↓ height of epith.**
- **↓ cilia**
- **↓ goblet cells**
- **No cartilage**
- **No glands**
- **No lymphatic nodules**
- **↑ smooth ms**
- **↑ elastic fibers**
- **↑ Clara cells**

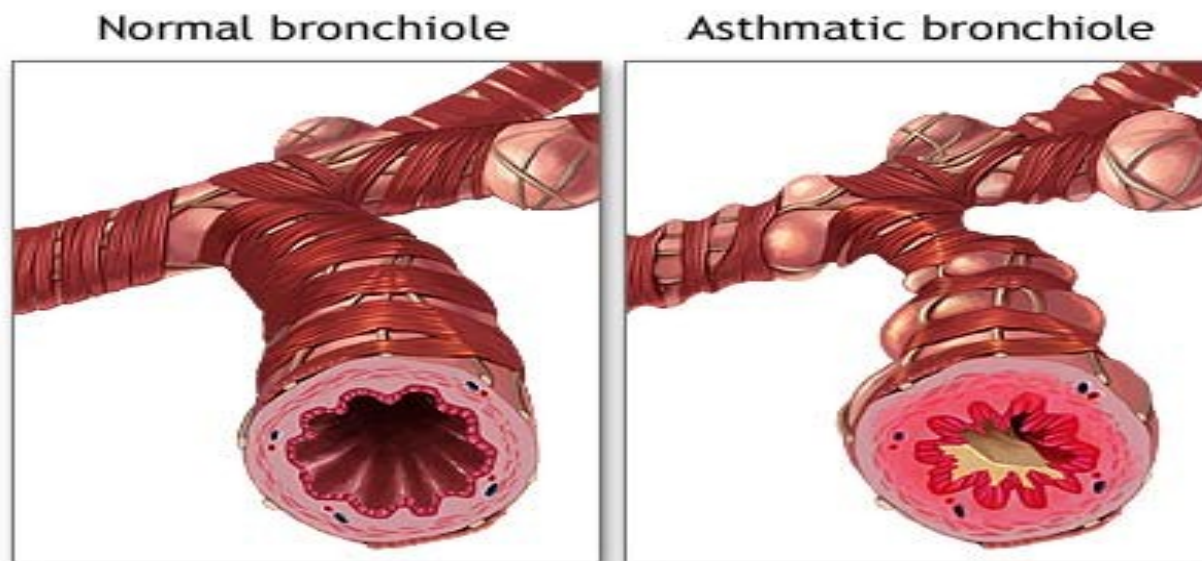


# Medical Application



## Bronchial asthma

- Sudden contraction of the bronchiolar smooth muscles increase air way resistance a condition known as asthma attack (Broncho-spasm).
- This is caused by **mast cell degranulation** triggered by specific antigens.







# Medical Application



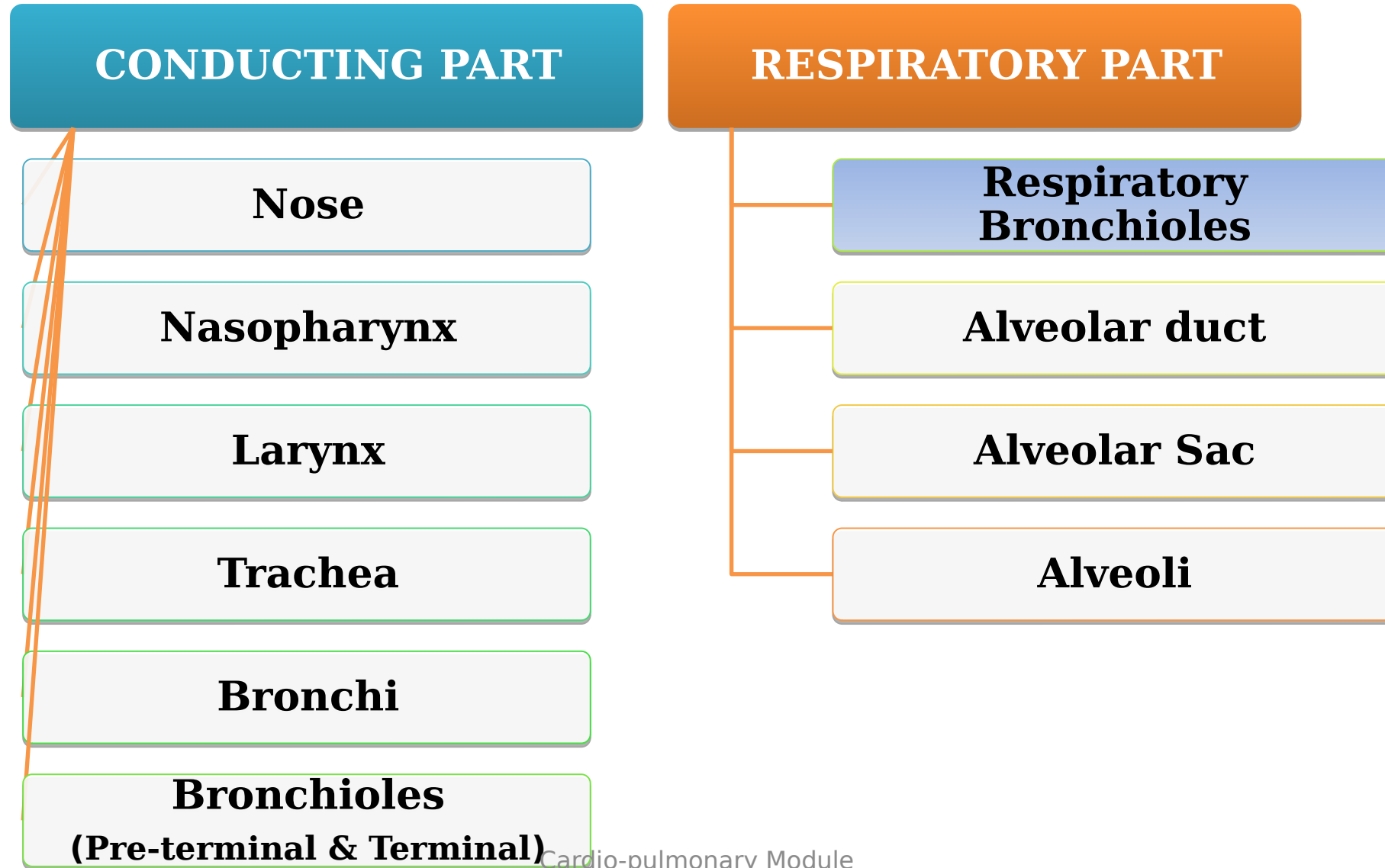
Chronic obstructive pulmonary disease  
(COPD)

**COPD affects the bronchioles and includes emphysema and asthma.**

- Emphysema is caused by a loss of elastic fibers in the interalveolar septa and results in chronic airflow obstruction.
- Asthma is a chronic process characterized by a reversible narrowing of airways.

☐ Asthma is reversible; emphysema is not.

# Components of Respiratory System



# Respiratory portion of the lung



- **Gas exchange can take place in components of this portion.**

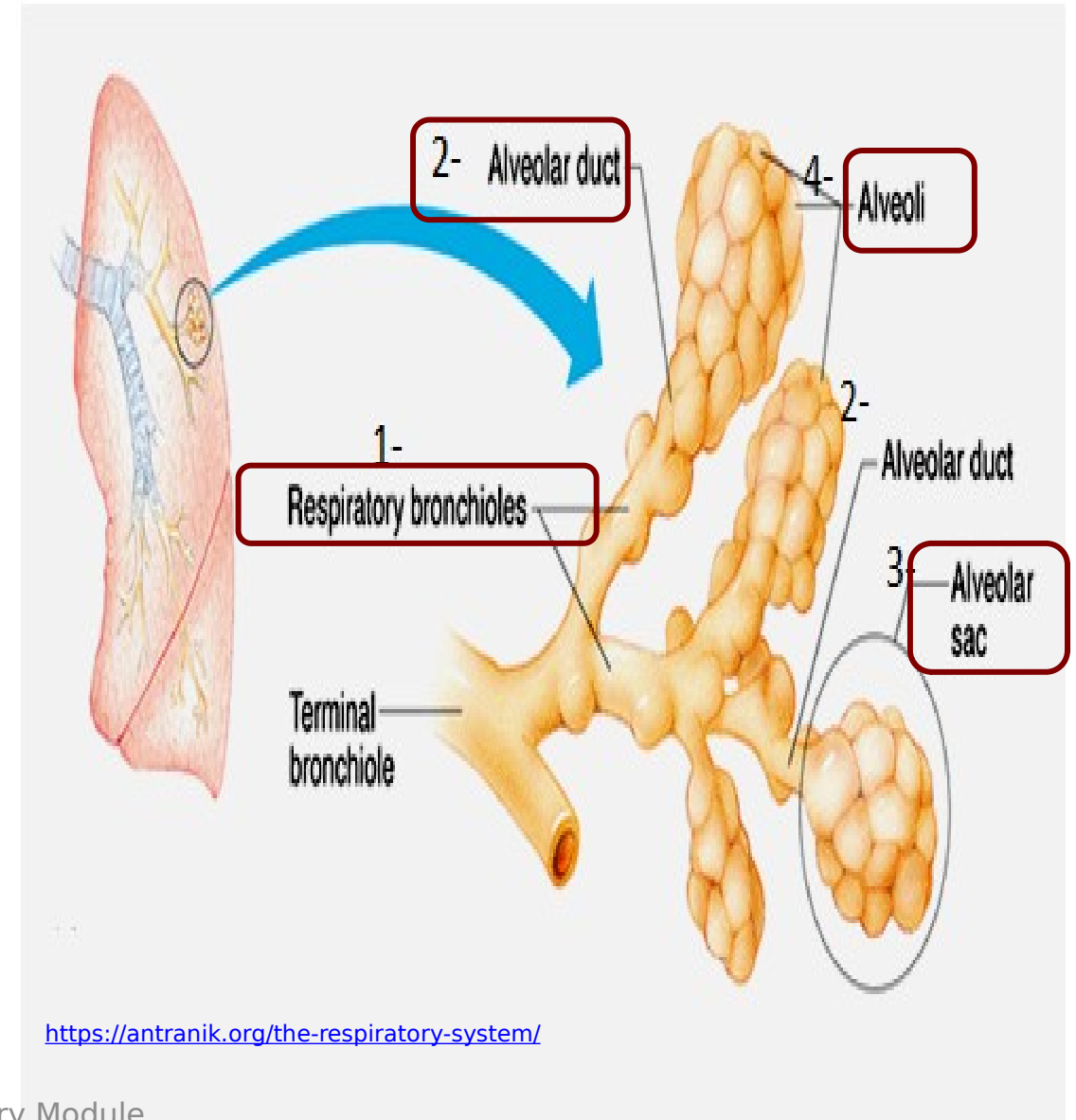
- **It is formed of:**

**1-Respiratory bronchioles**

**2-Alveolar ducts**

**3-Alveolar sacs**

**4-Alveoli**





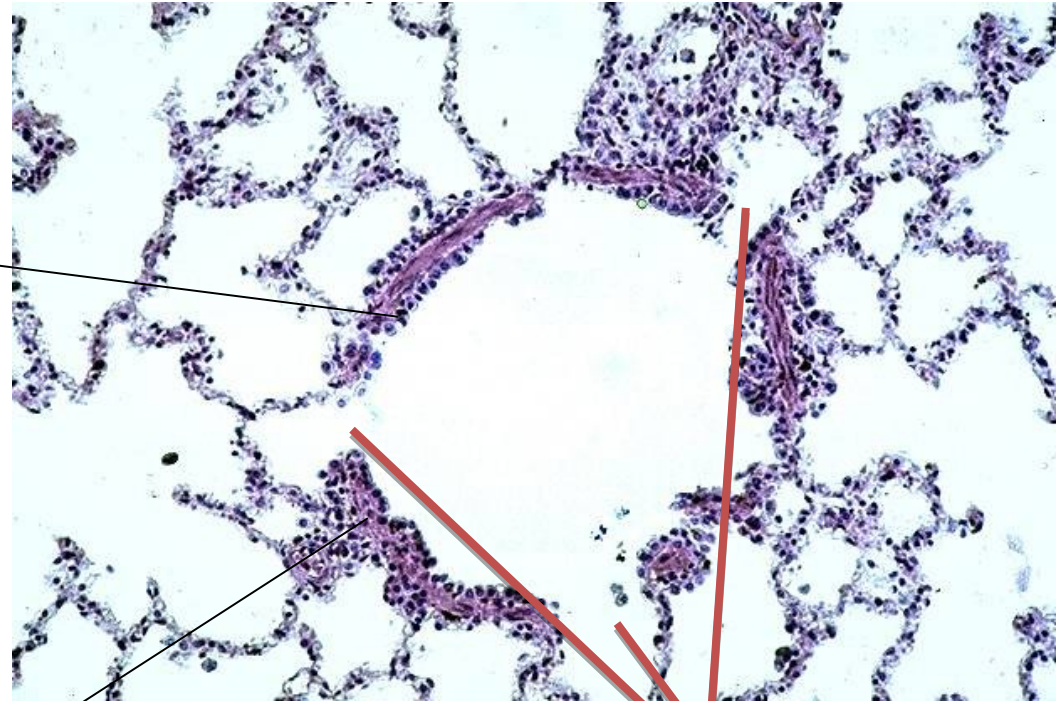


# 1- Respiratory bronchioles

They are the transition from the conducting to the respiratory portions.

It is **lined by simple cuboidal epithelium and Clara cells.**

• The underlying CT **lamina propria**, containing elastic and few smooth muscle fibers.

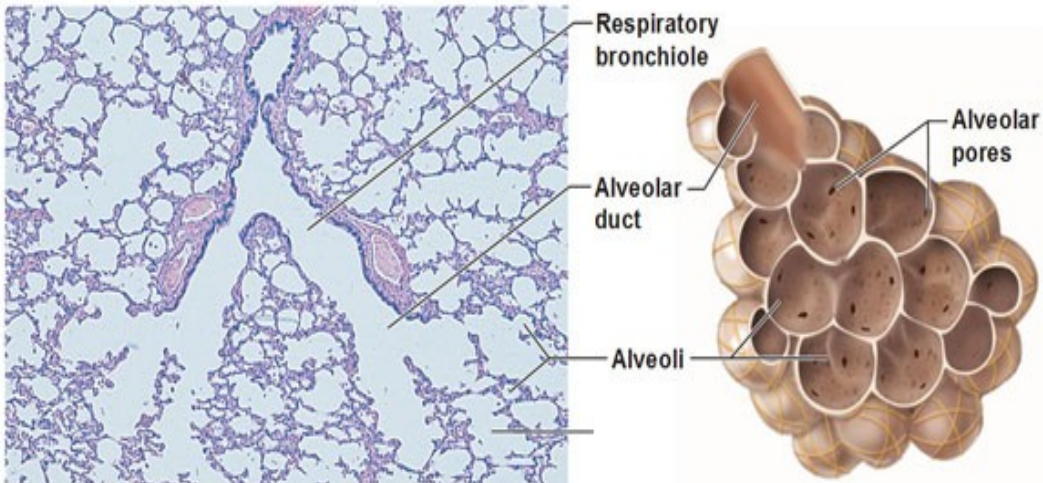


[https://kpfu.ru/portal/docs/F\\_67674169/DYKhATELNAYA\\_sistema.pdf](https://kpfu.ru/portal/docs/F_67674169/DYKhATELNAYA_sistema.pdf)

**Its wall is interrupted by alveoli....hence the name**

# Alveolar -2 ducts

- It is long branching passage arise from respiratory bronchioles.
- They have almost no walls, only alveoli.
- They are the **last portions that contain smooth muscle**



# Alveolar sacs -3



- They are group of alveoli which open into a common central space.
- **Structure:**
  - They are lined by simple squamous epithelium.
  - Beneath the epithelium, **reticular** and **elastic** fibers are present supporting the wall.

# Alveoli-4



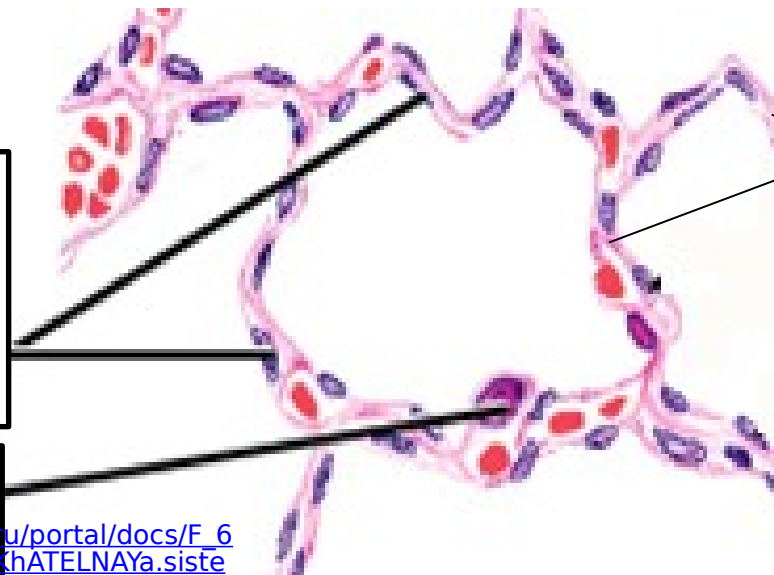
- They are minute air spaces that open into alveolar ducts and respiratory bronchioles.
- They are the **basic structural and functional units** of gas exchange in the lung.

• They have thin walls.

They have thin wall which allow CO<sub>2</sub> and O<sub>2</sub> exchange between blood and inspired air.

• They are lined by **alveolar epithelium** (pneumocytes type I & II).

[https://kpfu.ru/portal/docs/F\\_67674169/DYKhATELNAYa.sistema.pdf](https://kpfu.ru/portal/docs/F_67674169/DYKhATELNAYa.sistema.pdf)



They are separated from each other by thin **inter-alveolar septa** → **highly vascular and rich in elastic fibers.**

# Alveoli -4



## 1-Pneumocyte I:

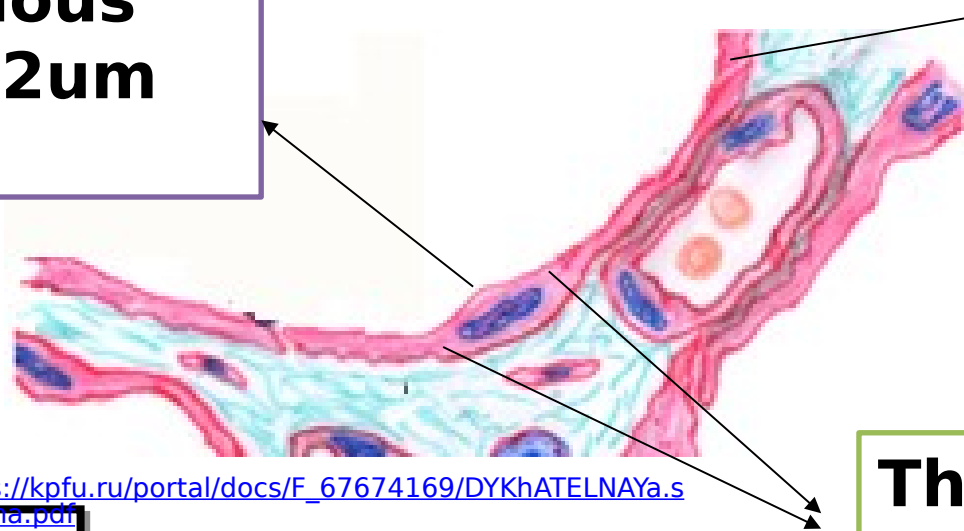
It covers about 95% of the alveolar surface.

They are not able to divide.

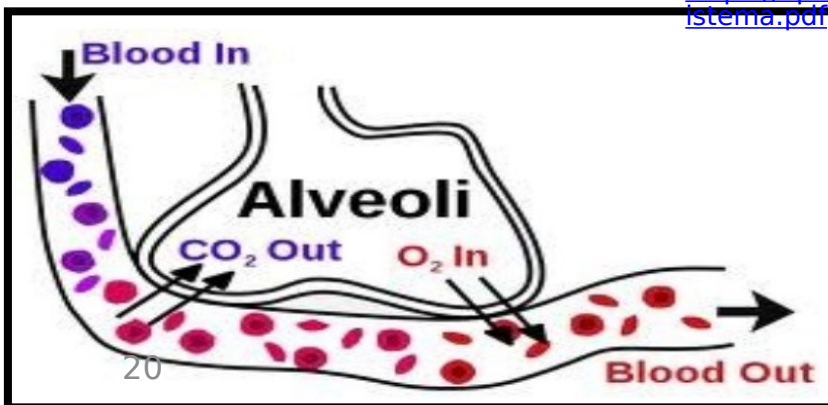
They are squamous cell less than 0.2um in thickness.

They are attached to each other and to type II cells by **occluding junctions**.

**Function:**  
Gas exchange

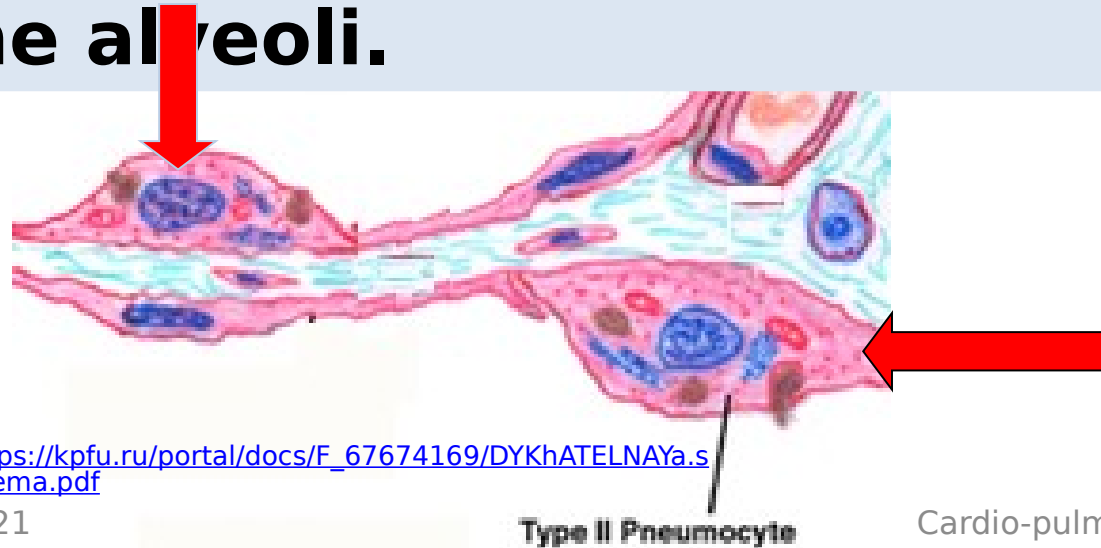


The perinuclear cytoplasm contains a small Golgi complex, few mitochondria and rER.



## :Pneumocyte II-2

- They are secretory **cuboidal** epithelial cells.
- They cover **5%** of alveolar surface.
- Located near the angles of the alveoli.



### Functions :

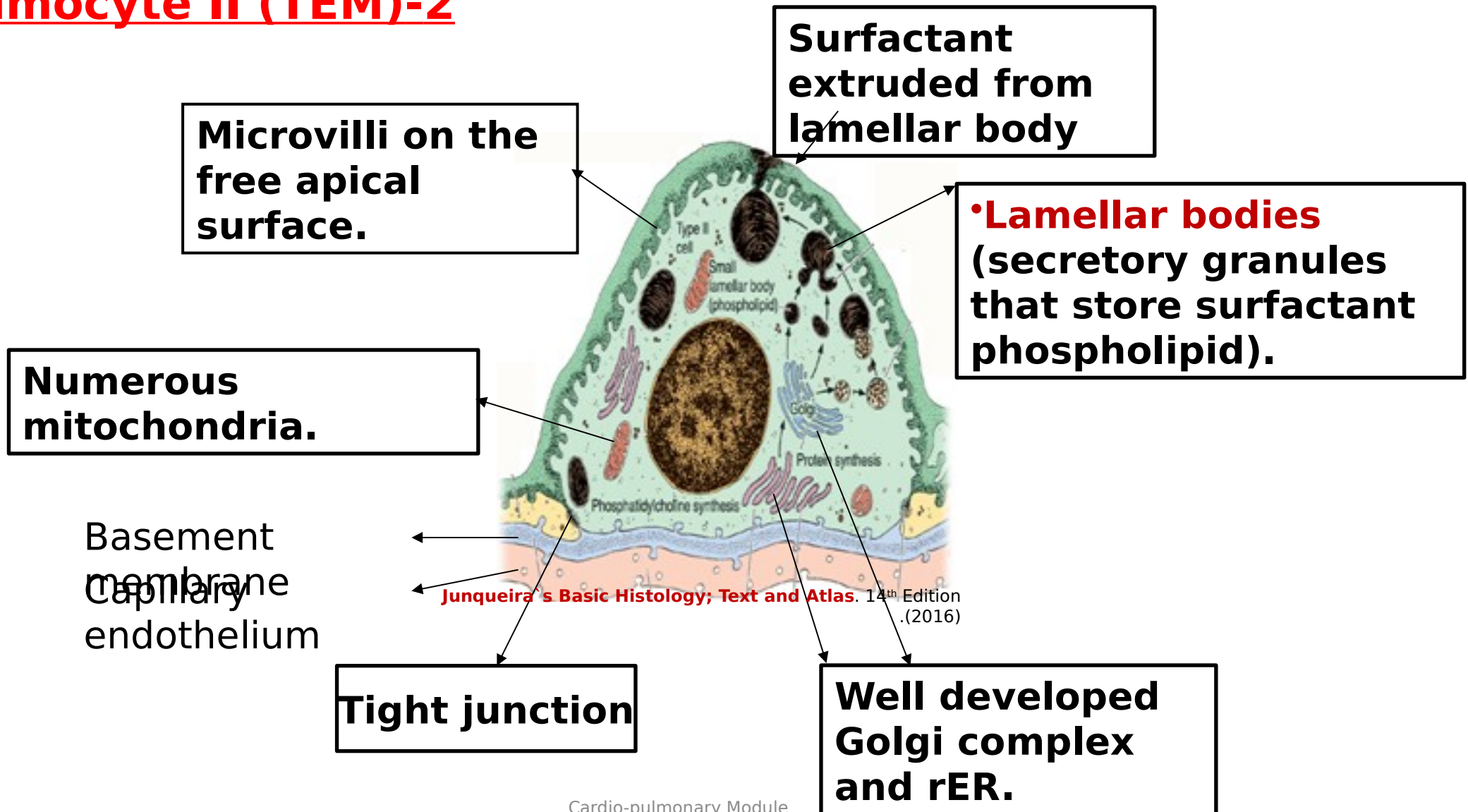
- 1-They synthesis and secrete pulmonary **surfactant** which is released by exocytose and spread over the wall of the alveoli.
- 2-They can **divide** and regenerate both types of pneumocytes.



# Alveoli -4



## :Pneumocyte II (TEM)-2

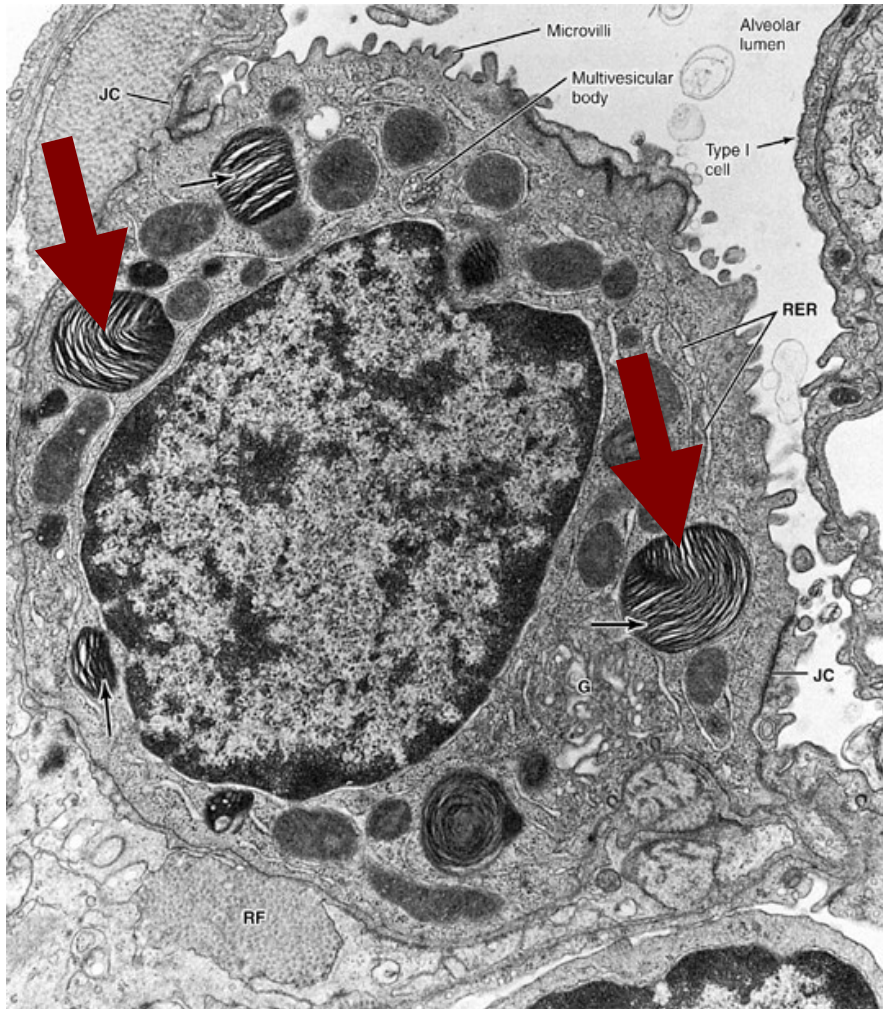


# Alveoli -4



## :Pneumocyte II (TEM)-2

Surface active  
agent



### ➤ Pulmonary surfactant:

- It is formed of phospholipid overlying a thin aqueous phase
- The surfactant is continuously synthesized by **type II pneumocytes**.
- It is phagocytosed by **alveolar macrophage** and **pneumocytes type II** (to be recycled).
- Function:
  - 1-It **lowers the surface tension** of the alveoli and prevents their collapse.
  - 2-Has a **bactericidal** effect

# Alveoli -4



@Dalia Matouk

**Alveoli**

Surfactant as  
detergent  
decreases surface  
tension



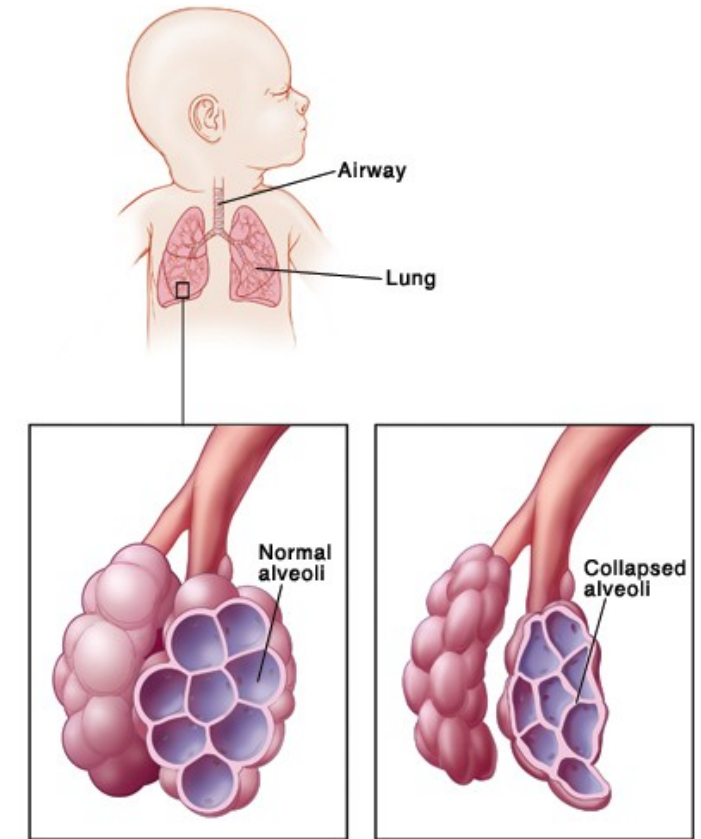


# Medical Application



## Neonatal respiratory distress syndrome (RDS)

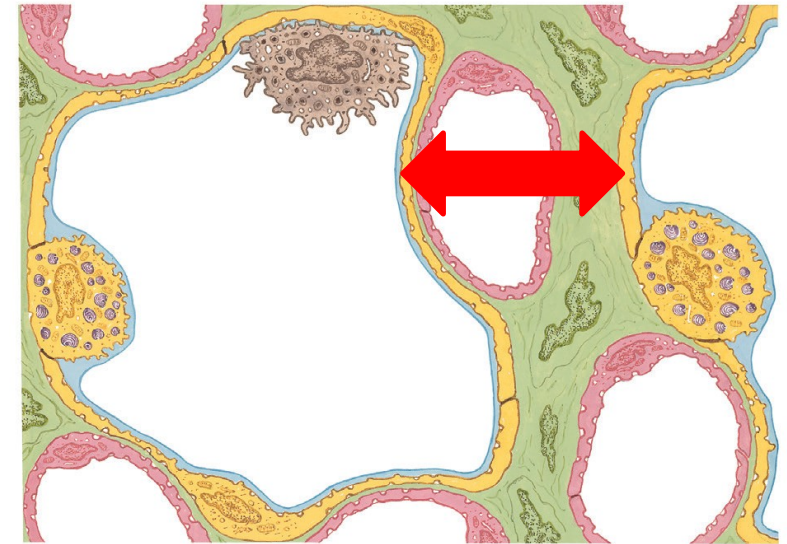
- Immature infants, ( born before 7 months) who have **inadequate supply of surfactant**, → suffer from inability to inflate lungs due to increased surface tension → fatal respiratory distress of the new born.
- These newborns are treated with a combination of **synthetic surfactant** and **glucocorticoid therapy**.



# Interalveolar septum



- **Definition:** It lies between the neighboring alveoli.
- **Structure:** It is formed of:
  1. Scattered fibroblasts
  2. Elastic and reticular fibers
  3. Richest capillary networks in the body
  4. Macrophages and other leukocytes can also be found



# Blood-air barrier



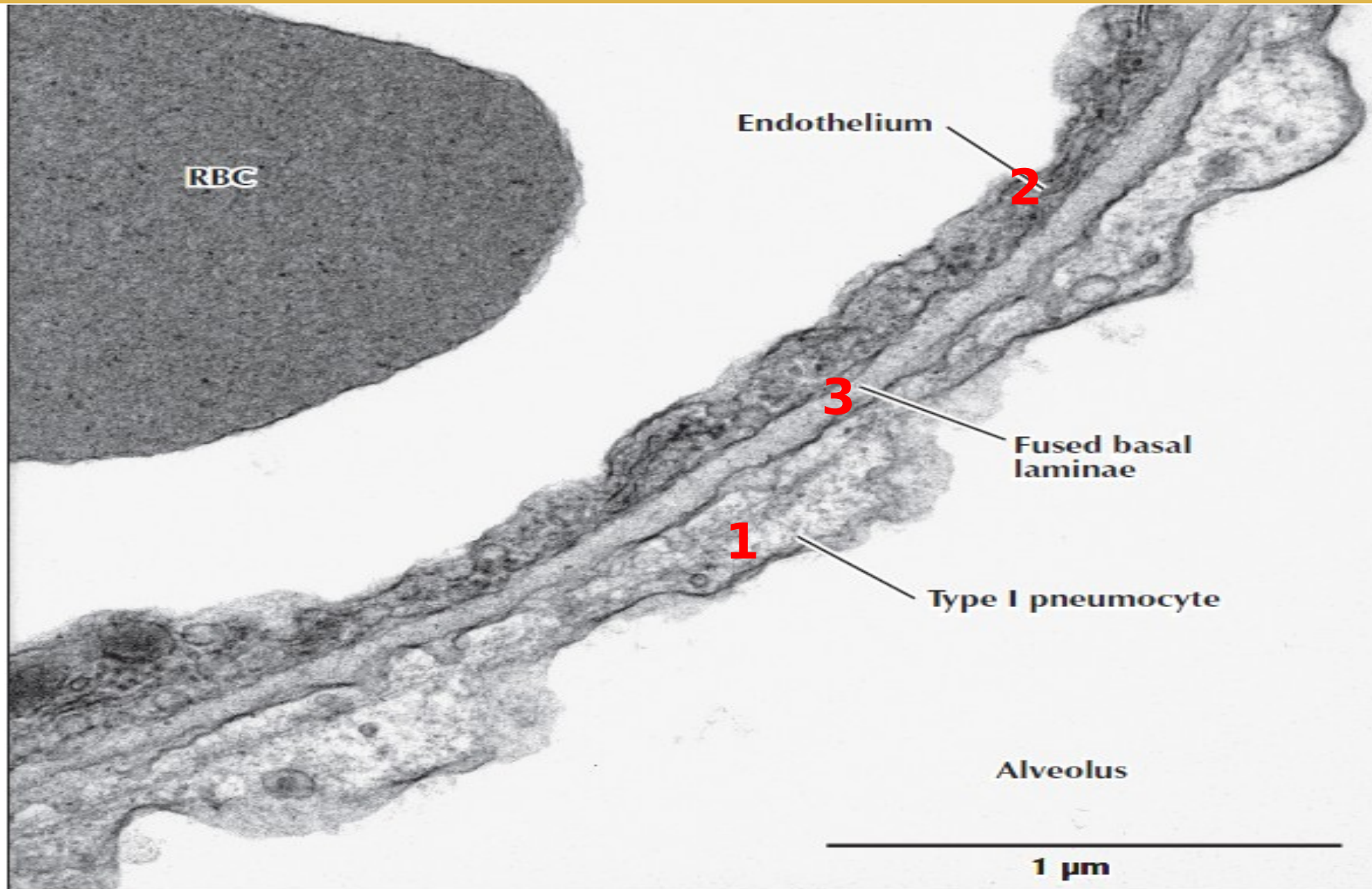
- **Definition:** It is the area of the inter-alveolar septum through which gas exchange occurs between the alveoli and blood in capillaries.
- **Structure:** It is formed of:



**Pneumocyte type 1 -1  
+  
thin layer of **pulmonary  
surfactant**  
endothelial cells and the  
alveolar epithelium  
forming **alveolo-capillary  
basement membrane.**  
2- Endothelial cells  
(**continuous type**)**

[https://kpfu.ru/portal/docs/F\\_67674169/DYKhATELNAYa.sistema.pdf](https://kpfu.ru/portal/docs/F_67674169/DYKhATELNAYa.sistema.pdf)

# E/M Blood-air barrier



[https://kpfu.ru/portal/docs/F\\_67674169/DYKhATELNAYa.sistema.pdf](https://kpfu.ru/portal/docs/F_67674169/DYKhATELNAYa.sistema.pdf)



# Alveolar Macrophage

## (Dust cell)



<https://www.studyblue.com/notes/n/pulmonary-i/deck/20635786>

- It is one of the mononuclear phagocytic system
- It is free migrating cell inside the lumen of alveoli

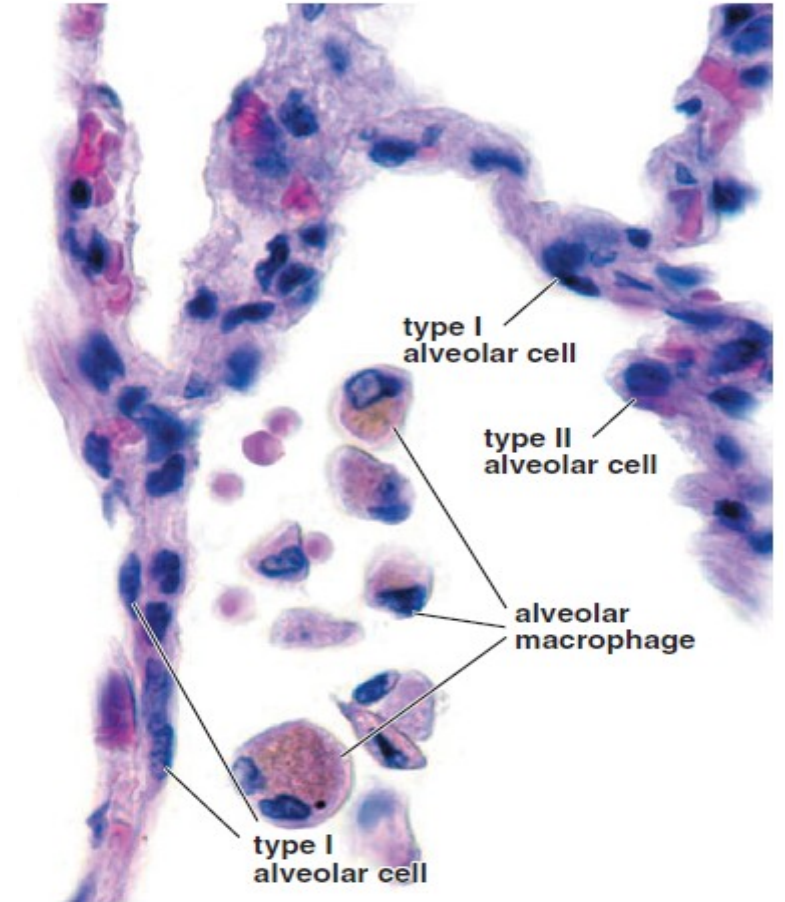
➤ **Origin:** monocytes

➤ **Function:**

- Phagocytose dust “**dust cell**”
- In congestive heart failure, they phagocytose extravasated blood “**Heart failure cell**”

➤ **Fate:**

1. Most migrate into bronchioles where they move up the mucociliary apparatus for removal into the esophagus.



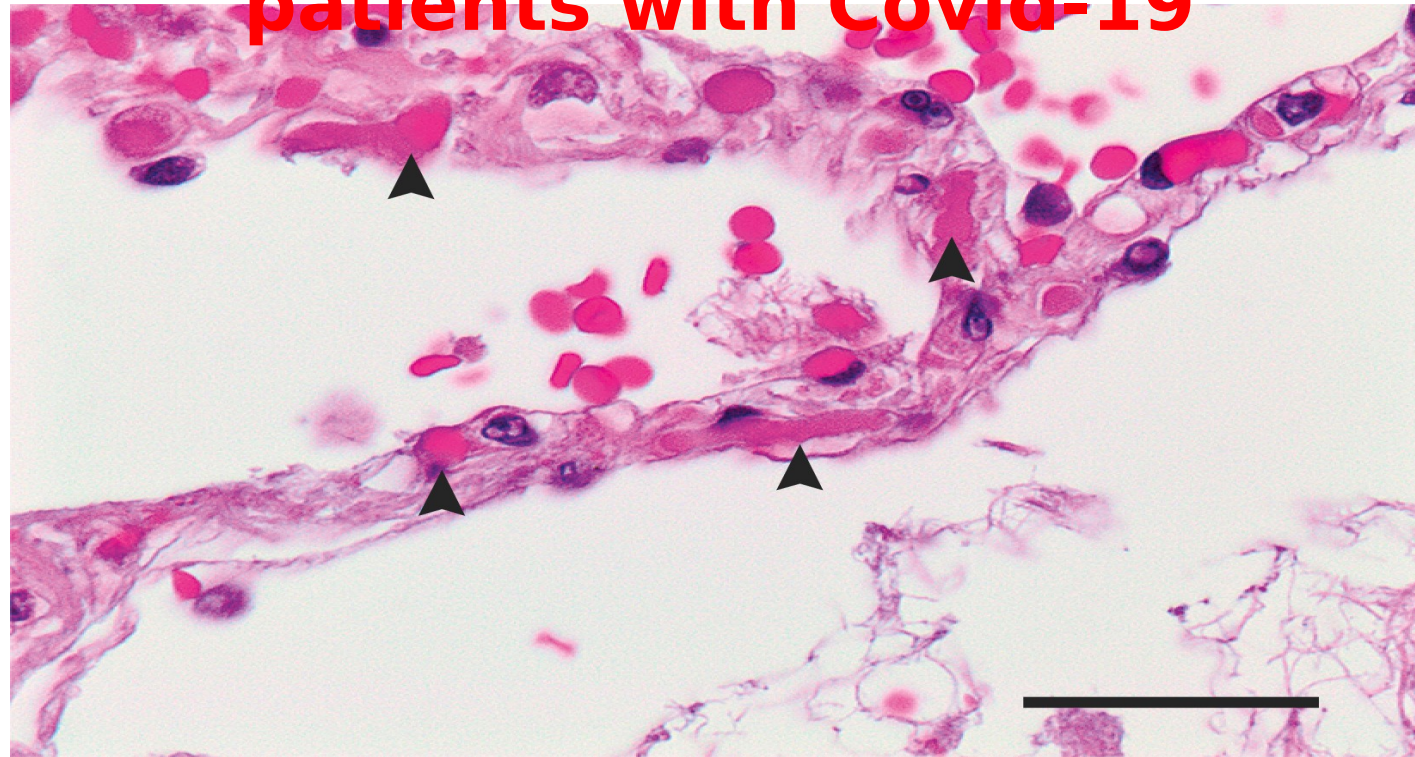
There are ~1-3 macrophages per alveolus.

They represent the last defense mechanism of the lung.



# Medical application

## ACE2-positive cells in the lungs from patients with Covid-19



<https://www.nejm.org/doi/full/10.1056/NEJMoa2015432>

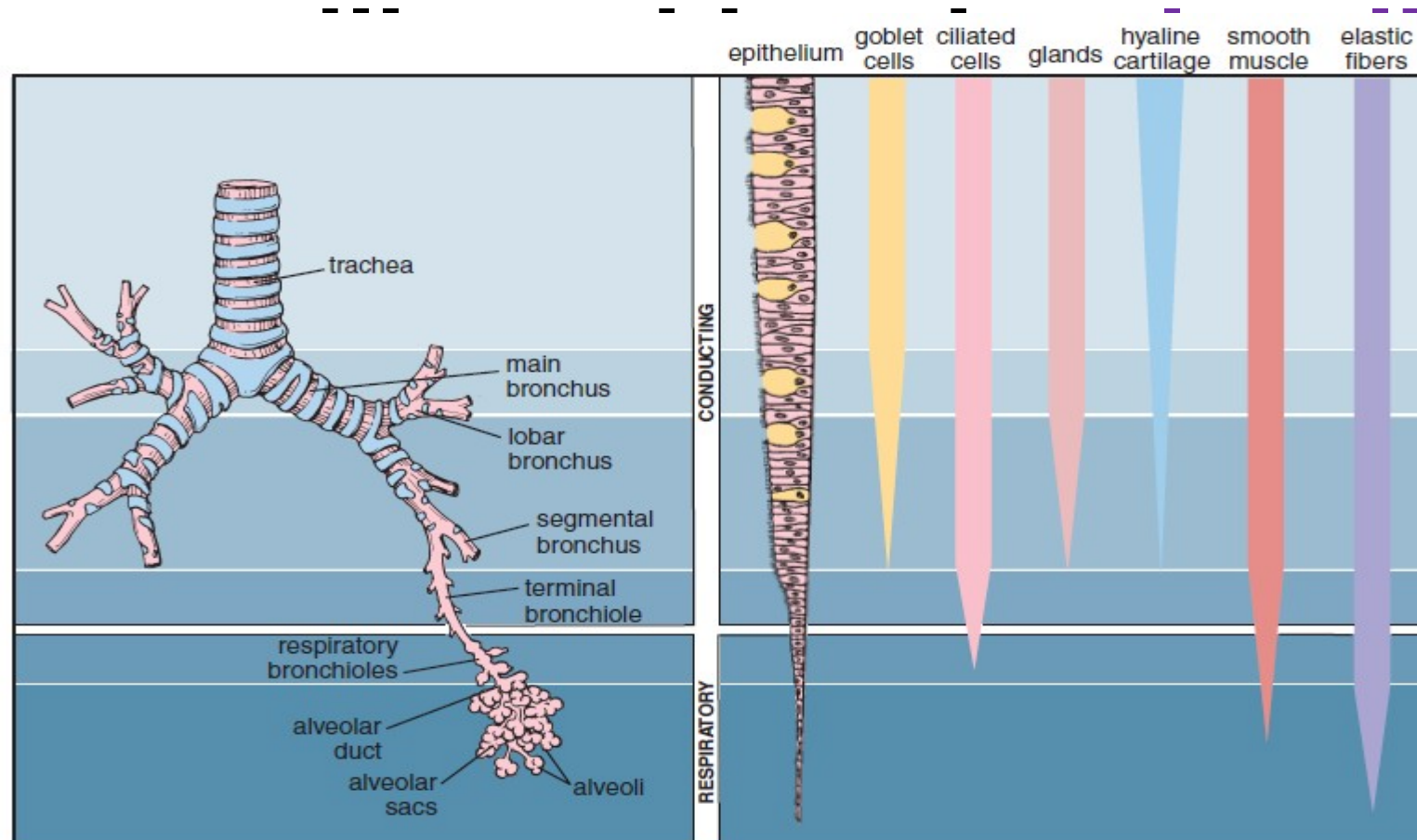
**Microthrombi in the Inter-alveolar Septa of Lung from a Patient Who Died from Covid-19**

Cardio-pulmonary Module

# Lecture Quiz



- Follow the epithelial lining of the respiratory tract beginning from the





• **The most distal part of respiratory system that contains smooth muscles in its wall *is which of the following structure?***

- a. Terminal bronchiole**
- b. Alveoli**
- c. Alveolar duct**
- d. Respiratory bronchiole**
- e. Alveolar sac**





- **Type II pneumocytes are characterized by all the following EXCEPT:**
  - a. Secrete surfactant**
  - b. Few in number**
  - c. Have microvilli**
  - d. Squamous cells**
  - e. Have lamellar bodies**

## Lecture Quiz



- **Pulmonary surfactant is characterized by which of the following?**
  - a. It rises alveolar surface tension**
  - b. It is manufactured by alveolar macrophages**
  - c. It has bactericidal effect**
  - d. It is synthesized by pneumocyte I**

# Summary



- A respiratory bronchiole leads to an **alveolar duct**, which is lined by a continuous series of alveoli and which ends in a cluster of alveoli called the **alveolar sac**.
- All alveoli are surrounded by sparse connective tissue in **interalveolar septa** that consist primarily of **elastic and reticular fibers** and a dense **capillary network**.
- The wall of each alveolus consists of two cell types: extremely **thin type I alveolar cells** and **cuboidal type II alveolar cells**.
- **Type II alveolar cells** are characterized ultra structurally by unique cytoplasmic **lamellar bodies**, large granules with closely stacked layers of membrane involved in **surfactant synthesis**.
- The **blood-air barrier** allowing gas exchange at each alveolus consists of the **thin type I alveolar cell**, the **thin capillary**

## SUGGESTED TEXTBOOKS



- **Mescher A (2021):** Junqueira's Basic Histology, Text and Atlas. 16th Edition. Lange medical books/Mc Graw-Hill.
- **Netter's Essential Histology.** 2<sup>nd</sup> Edition (2013).

THANK

YOU